



# Energy Commission

## Emerging Technology Research

**Michael Gravely**  
**Manager**

**Energy Systems Research Office**  
**California Energy Commission**

**[mgravely@energy.state.ca.us](mailto:mgravely@energy.state.ca.us) / 916-651-0316**

# Potential R&D Outcomes from Today's Workshop



- Clarification and better understanding of current emerging technology efforts and activities
- Future load management standards and or directives that result in new RD&D needs
- New RD&D topics or areas of interest that evolve from follow-on discussions and activities

# ET Research Ongoing at all Levels



## Transmission



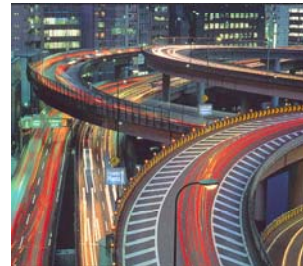
- Phasor Measurement
- Advanced displays
- Advanced comm & controls
- MRTU interface
- Energy Storage
- Renewables

## Distribution



- Distribution Automation
- AMI
- Advanced C&C
- MRTU
- Energy Storage
- Renewables
- AMI

## Integration



- Renewables
- Standards
- Protocols
- Reference designs
- Micro Grids
- Automation

## Consumer

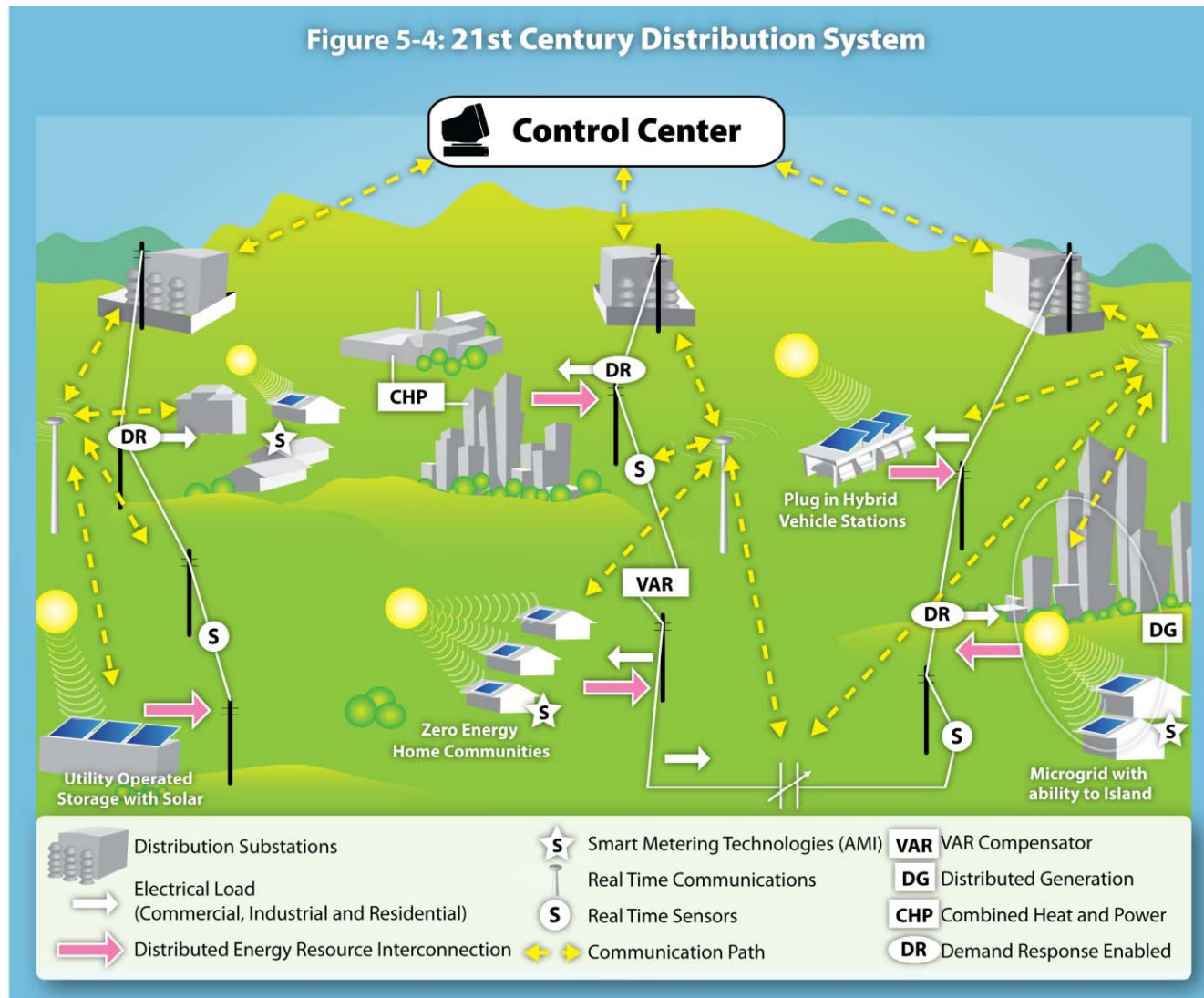


- Automating Demand Response
- AMI
- Dynamic Rates
- Home Area Networks
- Plug in Hybrids
- Renewables

# Utility Grid of the Future (Smart Grid)

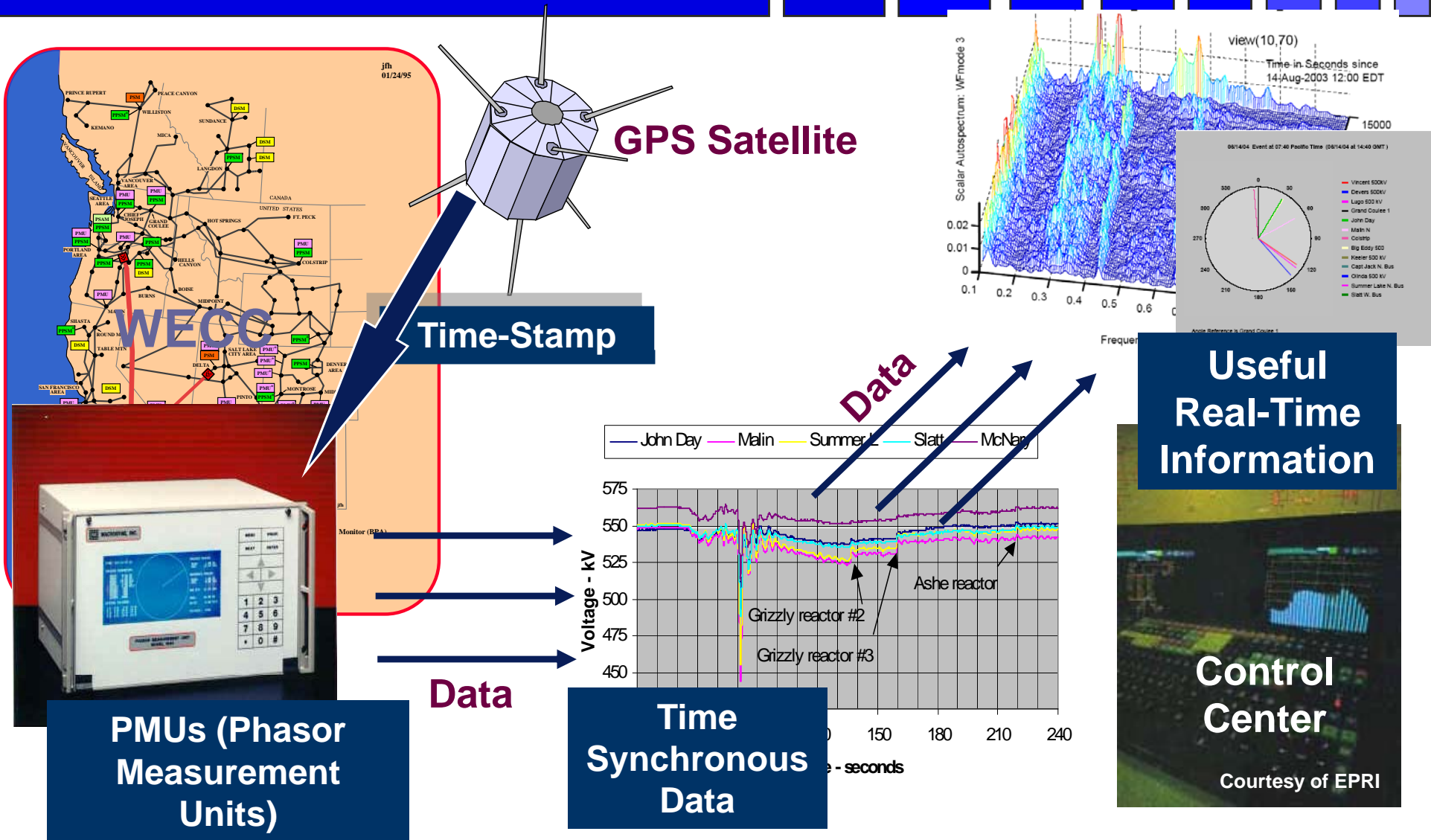


Figure 5-4: 21st Century Distribution System



Source: 2007 Integrated Energy Policy Report

# Transmission Research—Phasor Technology



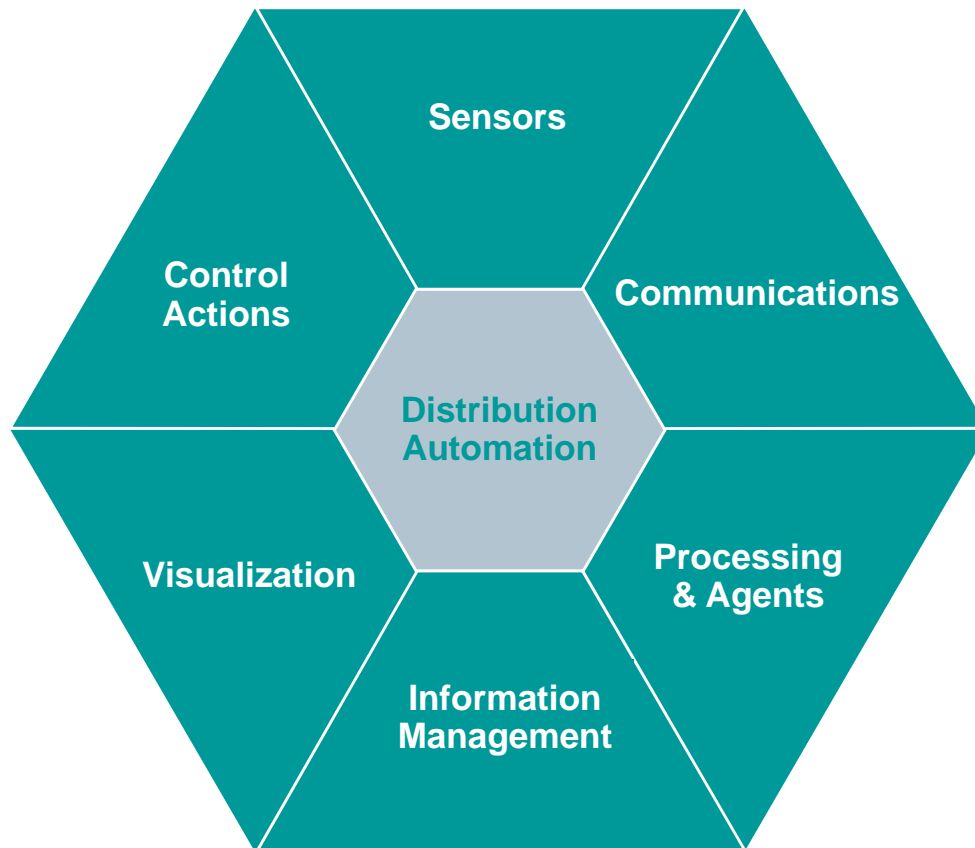
**Storyline: Real Time Phasor System from Concept to Control Room**



# Distribution Automation Research



Distribution Automation is a family of technologies that can perform certain distribution system operations with reduced human contact and involvement.



## **Sensors**

- Underground cable condition detection
- Low impact fault detection

## **Communications**

- PV/utility communications
- New/legacy equipment interface

## **Information Management**

- DER information model and communications
- Renewable Data Integration/Standards (61850)

## **Multiple Areas**

- Value of DA Study
- Utility-scale Smart Grid Demonstrations (micro-grids)

# Automation of Demand Response

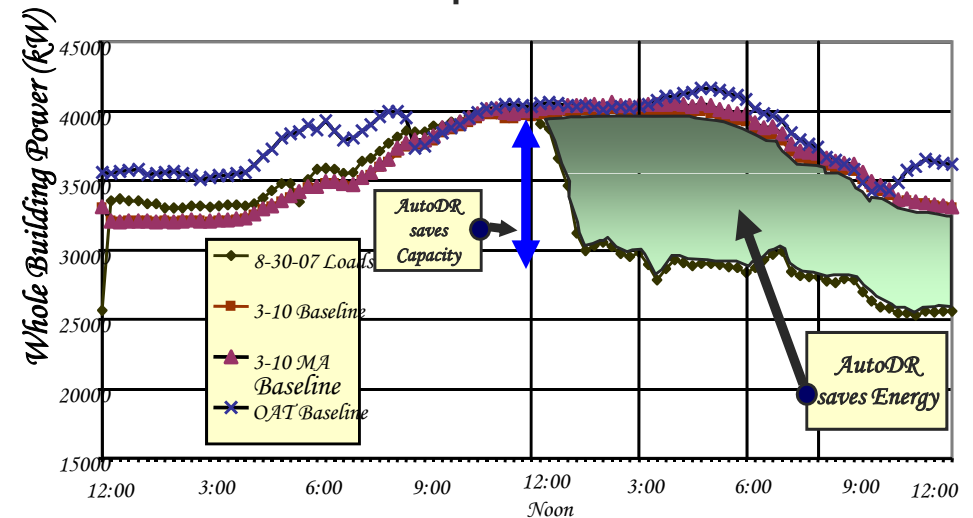


## Auto-DR 2007 Results

	2006	2007*
Total Participants	13 CPP	37 CPP 53 DBP 62 CBP 152 Total
Total Base load	8 MW	80 MW
Total Peak Load Reduced	1 MW	25 MW
Average Peak Load Reduction	13 %	34%

\* Includes large industrial loads.

PG&E AutoDR Test Day – All AutoDR Participants – 8/30/07



# DR as Spinning Reserve or Ancillary Service



In normal operations, CAISO routinely sends dispatch instructions to electricity generators to follow changes in electricity demand

Electricity flows from generators over transmission lines to distribution circuits and ultimately to customers' homes

In this demonstration project, CAISO sends test dispatch signals to SCE using the same protocol normally used to dispatch electricity generators

SCE records the time **1** that it receives, via pager or email notification, CAISO's request

SCE sends radio dispatch signals to 1,000+ air conditioning units located in the four test distribution circuits that are part of demonstration and records the time when the signal is sent **2**



14:40:00 **1**



14:40:05 **2**



Simi Valley

High Desert

Inland Empire

Temecula Valley

3 14:40:15

www

A statistically drawn sample of 100 controlled air conditioning units records the time when the curtailment signal is received **3** and sends real-time data on the units' electric power demand using cell phone-based meters

Electricity flowing to each of the four test distribution circuits is recorded in real time **4**

4 14:40:15

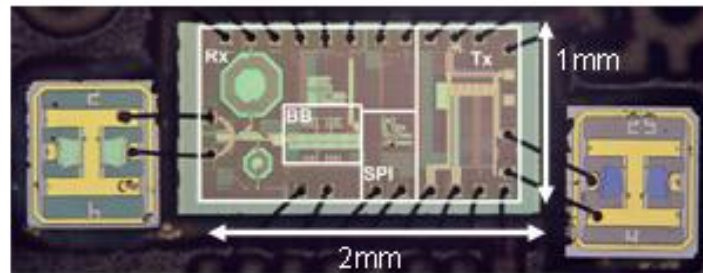
www

CERTS-SCE Demand Response Spinning Reserve Demonstration



## Recent Enabling Technology Development Research Projects

**Smaller, cheaper radio components...**

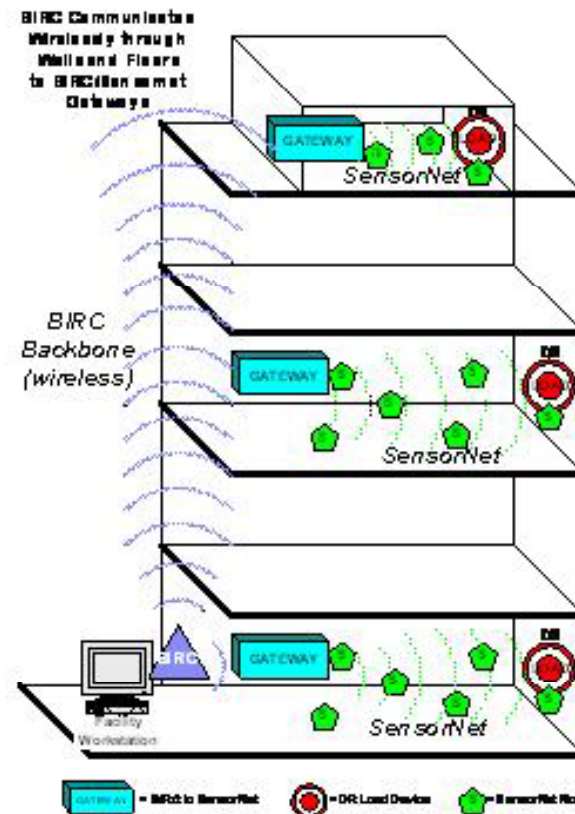


... leads to smaller, cheaper DR enabling technologies

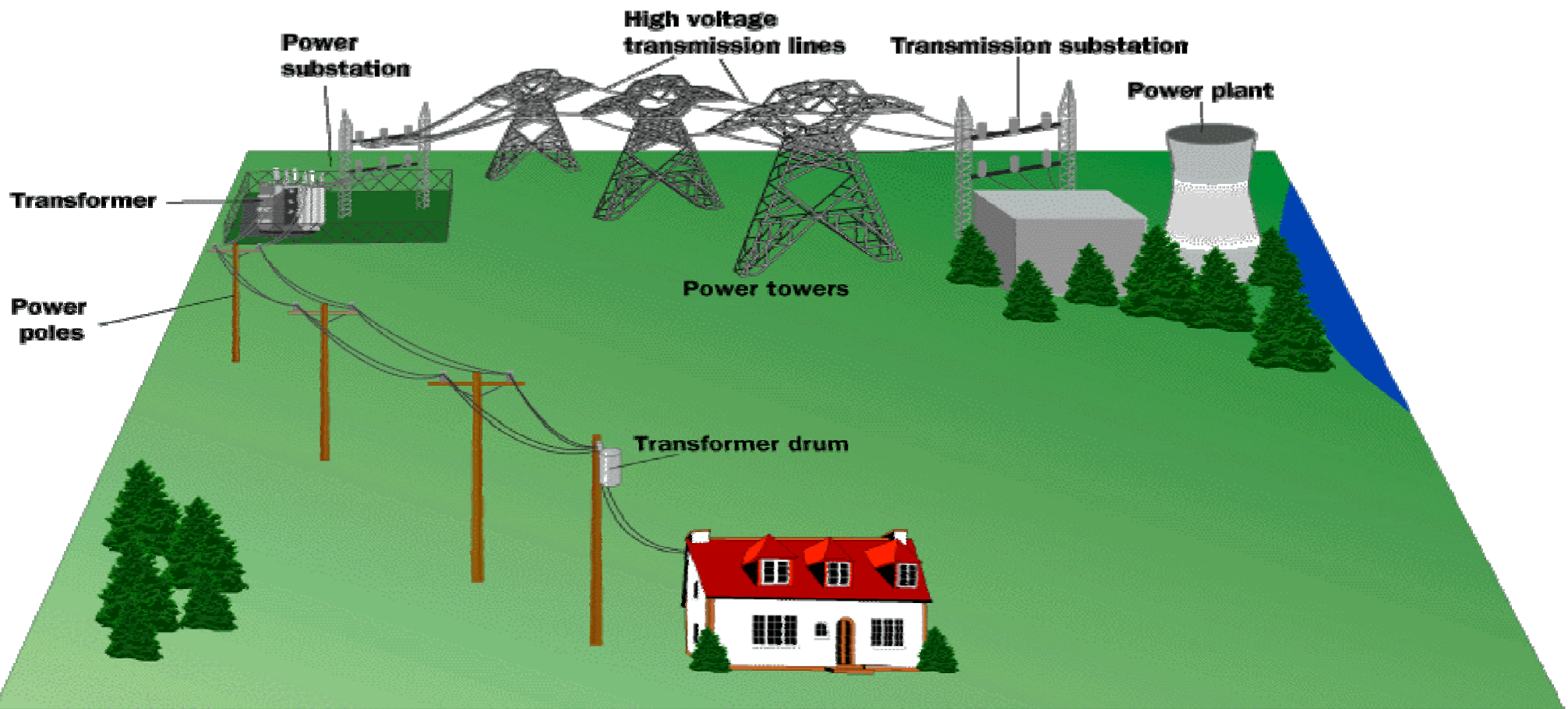


## Barrier Immune Radio Communications

Studying how different communication signals propagate through different building materials.



# Grid Security





# Energy Storage Technologies



COPYRIGHT 2001,  
ELECTRIC POWER RESEARCH INSTITUTE

100 kW, 15 kWh li-ion battery for UPS applications



Photo Courtesy of Salt America

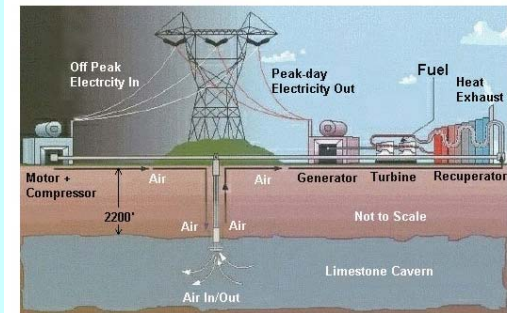


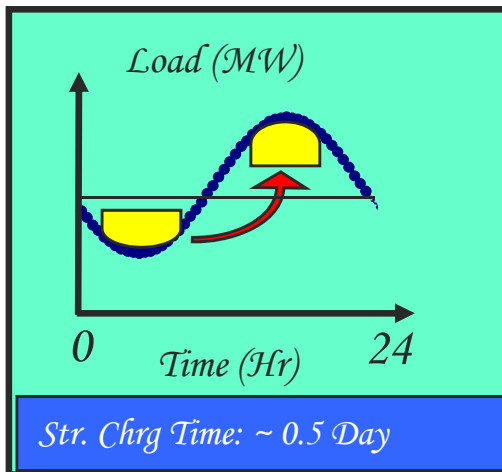
Photo Courtesy of CAES Development Company



# Energy Storage Applications in California

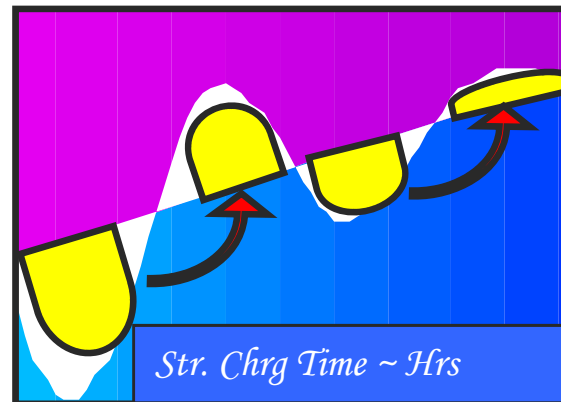


## Load Leveling



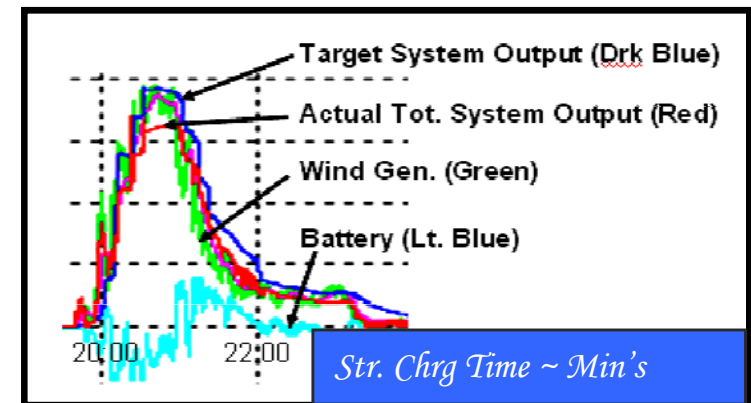
- CAES
- Pumped Hydro

## Ramping:



- CAES
- Pumped Hydro
- Battery, Flow type
- Note: In California ramping is a big issue

## Frequency Regulation:



- Battery, Regular or Flow Type
- SuperCap
- Flywheel
- SMES



# Capital Cost Comparison of Energy Storage Plant Types



Technology	\$/kW	+	\$/kWh*	x	H	=	Total Capital, \$/kW
<b>Compressed Air, CAES</b>							
- Large (100-500 MW)	440		1		10		450
- Small (10-20MW) AbvGr Str	600		80		2		760
<b>Pumped Hydro, PH</b>							
- Conventional PH (1000MW)	1300		40		10		1700
<b>Battery, BES (target) (10MW)</b>							
- Lead Acid, commercial	250		300		2		1150
- Advanced (NaS/Flow)	250		500		2		1250
<b>Flywheel (target) (100kW)</b>	250		700		2		1650
<b>Superconducting (1MW)</b>	200		1000		2		2200
<b>Magnetic Storage, SMES (target)</b>							
<b>Super-Capacitors (best today)</b>	250		12000		1/60		450
<b>(target)</b>	250		1200		1/60		270

\* This capital cost is for the storage "reservoir", expressed in \$/kW for each hour of storage. For battery plants, costs do not include expected cell replacements. EPRI updates these plant costs as technology improvements occur.



- **Developing energy storage operational envelopes for use with CA SIO Ancillary Services**
  - Help remove obstacles for use of energy storage technologies
- **Assessing value of energy storage to the integration of renewables in California**
- **Assessing use of energy storage to permit 24-hour use of renewables in California**
- **Support key energy storage demonstration projects**

# Follow-up Questions



**Michael Gravely**  
**California Energy Commission**  
**[mgravely@energy.state.ca.us](mailto:mgravely@energy.state.ca.us)**  
**916-651-0316**